Climate Change Science Institute Overview

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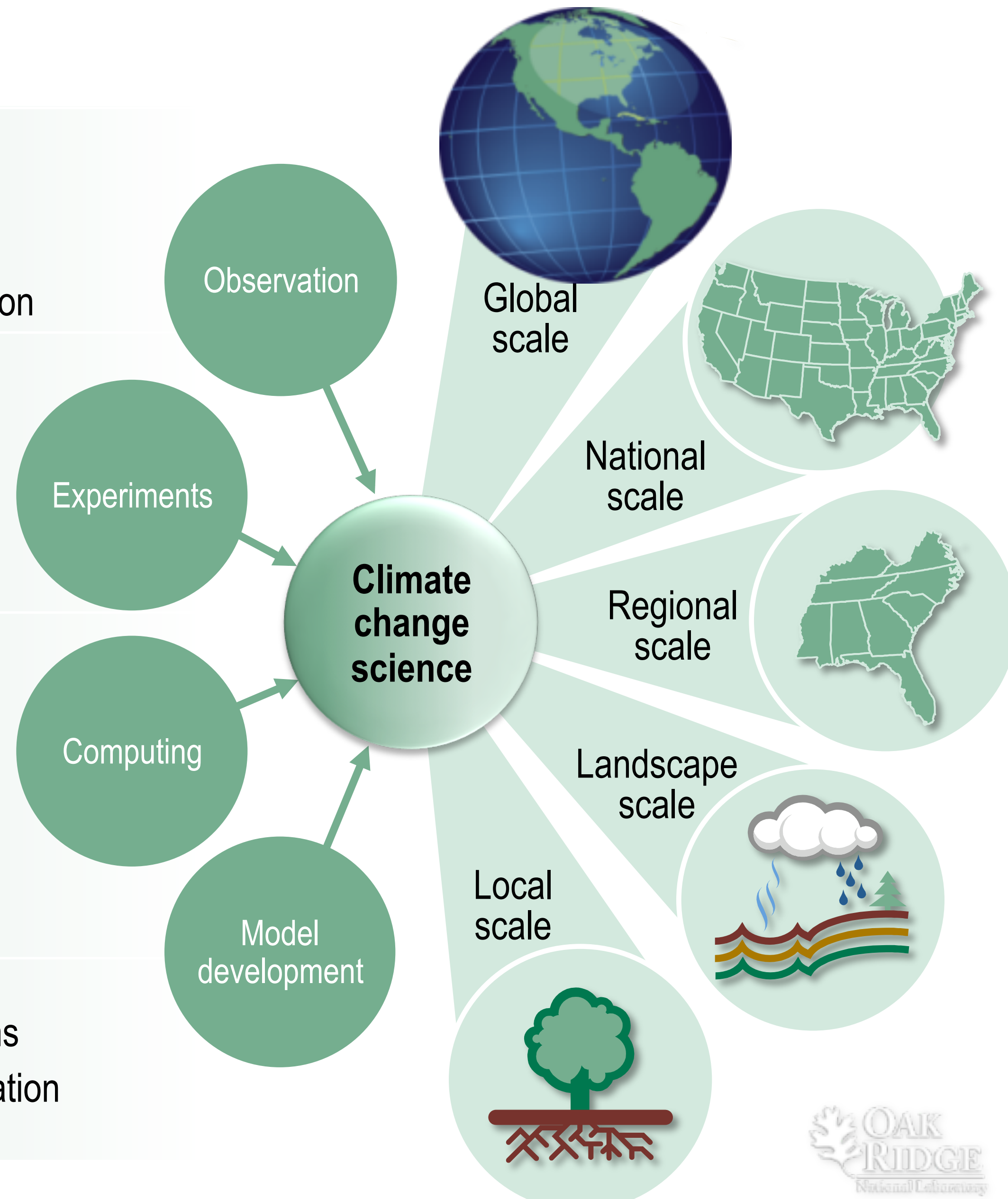
Climate Change
SCIENCE INSTITUTE

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY

We focus on accomplishments in four Thrust Areas

Earth System Modeling	• High resolution • Decadal-scale projections • Uncertainty quantification • Improved process representation
Data Integration, Dissemination & Informatics	• Adaptable and accessible information systems to integrate diverse data from observations and model results (gridded, point, images, etc.)
Terrestrial Ecosystem and Carbon Cycle Science	• Next-generation experiments • Remotely-sensed data • Biogeochemical cycles: (e.g., C, N, P, H_2O) • Greenhouse gas emissions from all sources
Impacts, Adaptation, and Vulnerability Analyses	• Link ESMs with observations through advanced data systems • Deploy rapidly to assess mitigation and adaption options

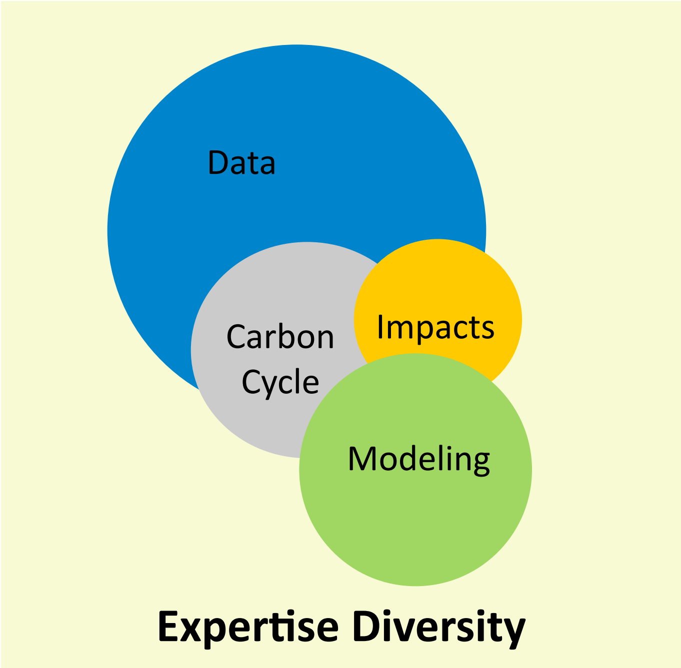


CCSI Objectives

- Develop, test, and apply improved high-resolution Earth System Models
- Develop advanced data systems to integrate observational data with simulation results
- Design, operate, and perform science on next-generation experiments to fill critical biogeochemical gaps in global climate models
- Develop methods to use model results to evaluate potential extreme events, quantify uncertainty, and improve assessments of impacts, adaptation, and mitigation options for climate change

Climate Change Science Institute

- Leadership
  - Jim Hack, Director
  - David Bader, Deputy Director
  - Gary Jacobs, Operations & Business Development Manager
  - 84 years of collective experience in climate change and its supporting sciences
- Staff
  - 81 staff
    - Significant growth occurring in Modeling and Impacts
  - Multi-disciplinary team fostering collaboration
- Funding
  - FY10 budget of $100+M



Residency for the Climate Change Science Institute

- Co-location of staff doing research relevant to climate change is desired
- We have identified space in the National Energy Security Building – (#2040)
- We will have ~100 offices to co-locate everyone
- Target date for moves is Sep 2010

Sponsors/Partners

Climate Change SCIENCE INSTITUTE

- DOE Office of Biological and Environmental Research
- DOE Office of Advanced Scientific Computing Research
- NASA
- DoD
- NOAA

We exploit our core competencies in partnership with others

Earth system models from local to global scales

- Atmosphere
- Ocean
- Ice
- Terrestrial carbon cycle
- Land use
- Hydrologic cycle

Process understanding: Observation, experiment, theory

- Aerosols, water vapor, clouds, atmosphere dynamics
- Ocean dynamics and biogeochemistry
- Ice dynamics
- Terrestrial ecosystem feedbacks and response
- Land-use trends and projections
- Extreme events, hydrology, aquatic ecology

Synthesis and analysis science

- Impacts
- Adaptation
- Mitigation
- Sustainable Energy, Food, Water, and Infrastructure
- Complex Considerations:
    - Societal decisions
    - Economics
    - Environment
    - Security

Partnerships are essential

High-performance computing

Data systems, knowledge discovery, networking

Observation networks

Experimental manipulation facilities

Core competencies
Competencies to build on
Partnership opportunities

Data Integration, Dissemination and Informatics

- ARM Data Archive
- Scaling the Earth System Grid to Petascale Data (ESG) LLNL (lead), ORNL, NCAR, ANL LANL
- Carbon Dioxide Information Analysis Center
- Ultra-scale Visualization Climate Data Analysis Tools. LLNL (lead), ORNL, LANL.- new
- Visual Data Exploration and Analysis of Ultra-large Climate Data, LBNL (lead), LLNL, ORNL, LANL - new

Strategies

- Utilize the Earth System Grid
  - Employ existing technologies
  - Develop next generation technologies for evolving needs
  - Backbone for federation with other facilities
- Deploy Data Engines
  - Computational capabilities to move intensive calculations/ analysis to server
  - Sit close to data archives
  - Host ESG and other middleware for data federation and integration
  - Hardware strategy to prevent obsolescence

Evolving ESG for the future

Earth System Grid

ESG Data System Evolution

2006

Central database

- Centralized curated data archive
- Time aggregation
- Distribution by file transport
- No ESG responsibility for analysis
- Shopping-cart-oriented web portal
- ESG connection to desktop analysis tools (i.e., CDAT and CDAT-LAS)

Early 2009

Testbed data sharing

- Federated metadata
- Federated portals
- Unified user interface
- Quick look server-side analysis with CDAT
- Location independence
- Distributed aggregation
- Manual data sharing
- Manual publishing

2011

Full data sharing (add to testbed…)

- Synchronized federation
  - ➢metadata, data
- Full suite of server-side analysis with CDAT
- Model/observation integration
- ESG embedded into desktop productivity tools with CDAT
- GIS integration
- Model intercomparison metrics
- User support, life cycle maintenance

CCSM AR4

ESG Data Archive

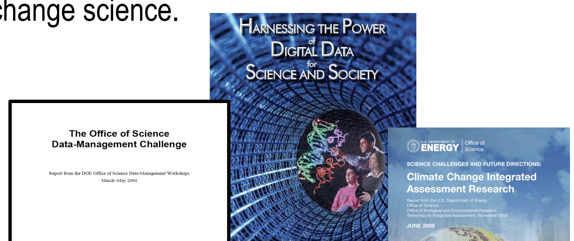
CCSM, AR5, satellite, In situ biogeochemistry, ecosystems

Terabytes **Petabytes**

Enhancing Climate Impact Integrated Assessment for Water Through Climate Informatics (LDRD Project ID 05528)

W. Christopher Lenhardt (ESD), Principal Investigator
Marcia Branstetter (CSM), Anthony King (ESD), Line Pouchard (CSM), Kao Shih-Chieh (ESD), Dali Wang (ESD), Co-Investigators

Numerous high-level reports highlight the need for advanced informatics and information science capabilities as applied to climate change science.



Informatics-Related Needs:

"Interoperable and accessible Modeling Frameworks and Collaborations• Interoperable input and output detail, timesteps, and scales • Interdisciplinary modeling environments • Agile modeling frameworks for approaching questions of different user communities • Community modeling approaches • Multiple models for scientific learning • Enabling computation and networks (high-performance computing) data development and accessibility• Observations: harmonizing regional data, dealing with sparse datasets, and incorporating and querying very large datasets• Data quality and verification • Data management, distribution, and access • Supporting cyber-infrastructure"

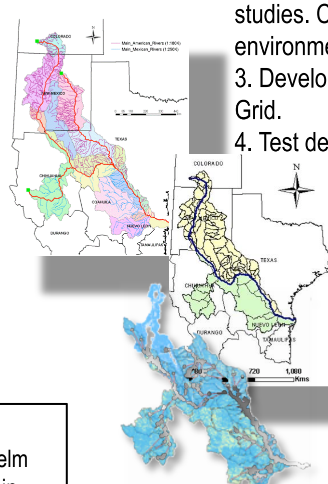
(DOE, Office of Science, *Climate Change and Integrated Assessment*, 2009)

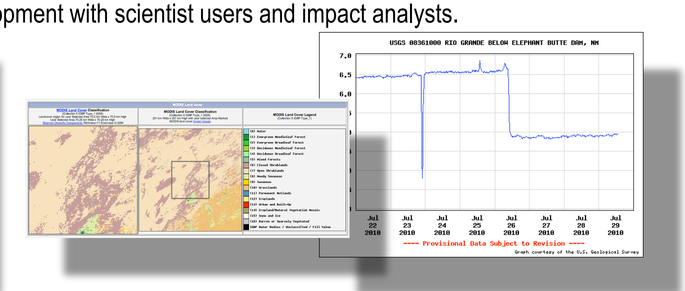
"All of these [climate change science-related] activities will overwhelm current capabilities and underscore the need for new technologies in data management and data analysis."

(DOE, Office of Science. *Data Management Challenge*, 2004)

CLIMATE INFORMATICS: The application of information science to capture scientific knowledge in the context of integrated climate and environment research.

Objectives:
1. Data: Gather extant water and hydrological data sources, as well as descriptive and ancillary data in one location accessible to ORNL scientists.
2. Tools: Ensure proper dataset annotations by bridging discipline specific metadata, and promote interoperability by creating metadata capture tools. Capture provenance trails of scientific knowledge as part of the scientific process, thus creating workflows for stream-flow analysis and impact studies. Create a virtual data set tool. Develop a digital object repository environment.
3. Develop tools to facilitate integration of this effort with the Earth System Grid.
4. Test development with scientist users and impact analysts.





Approach:
Develop capabilities in the context of use cases to support climate change science research scenarios for the Rio Grande River watershed.

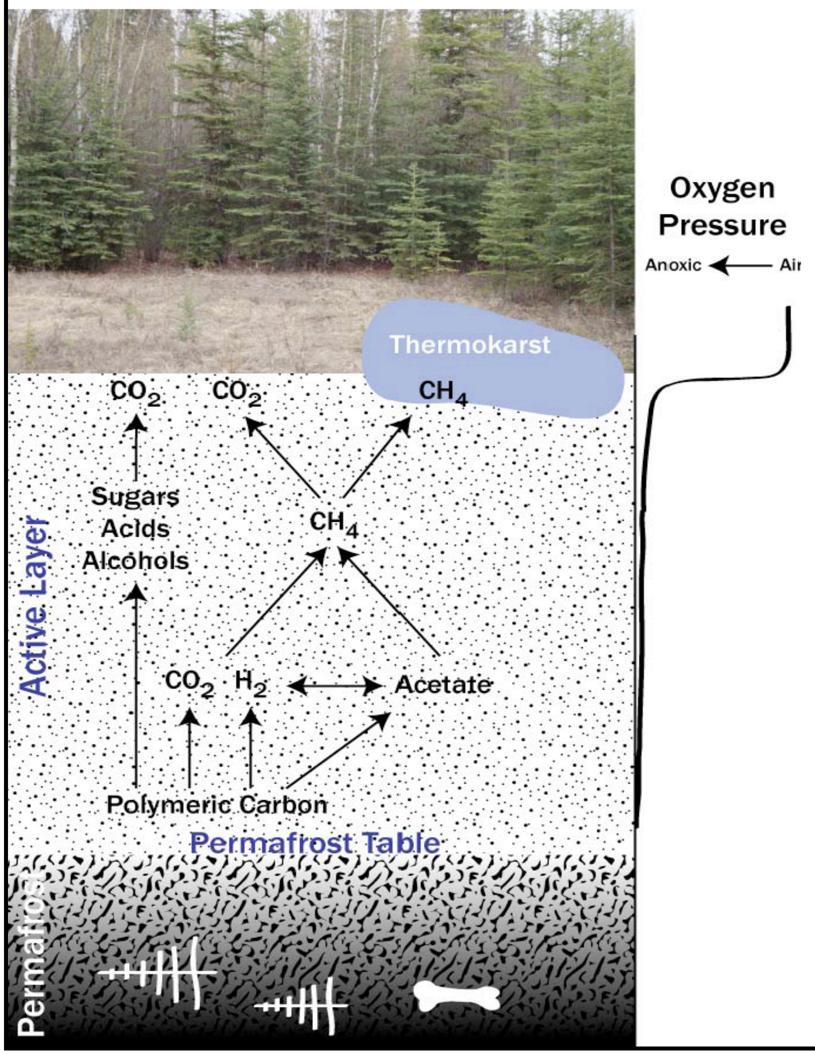
Impact:
A climate informatics capability will enable enhanced science, knowledge capture, and knowledge creation and serve as an important capability bridging the realms of high performance computing and domain science.

Research sponsored by the Laboratory Directed Research and Development Program of Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U. S. Department of Energy

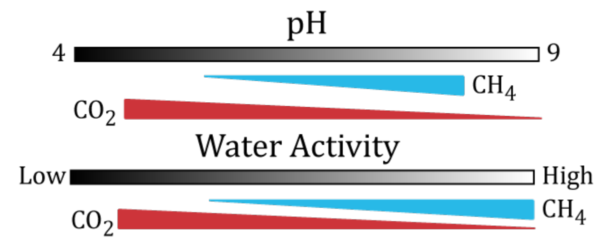
Characterization and Modeling of Permafrost Microbial Community Diversity and Metabolism during Simulated Global Warming

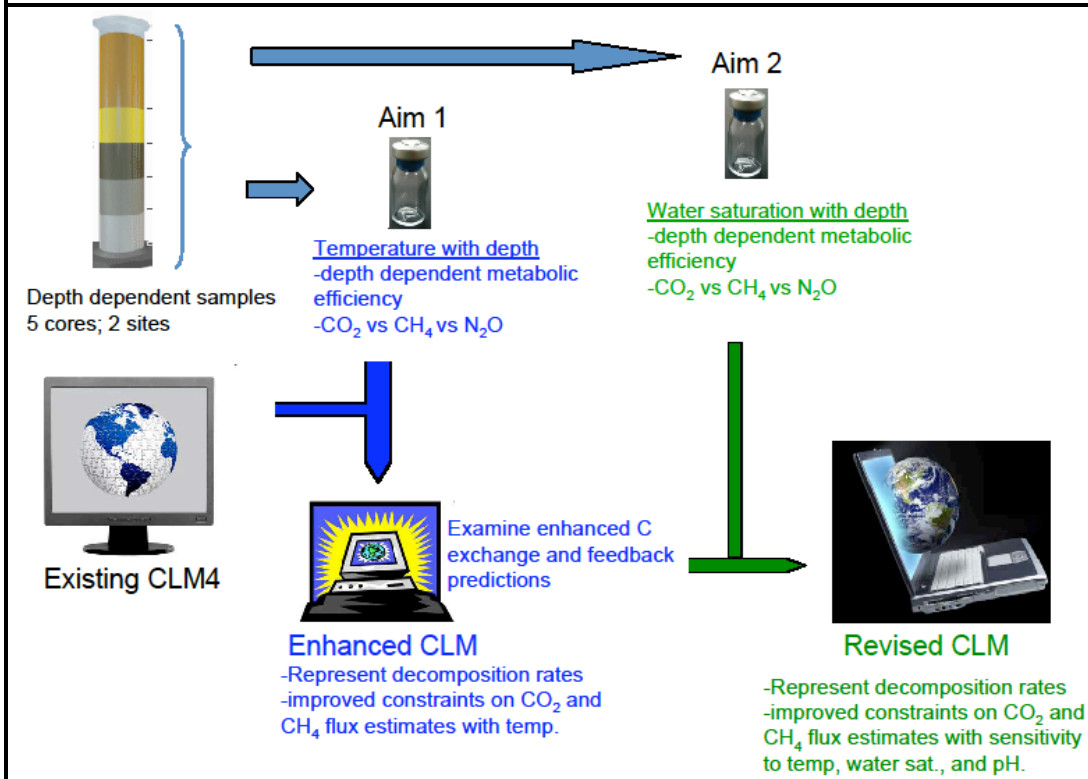
PI: Elias (BSD), Graham (BSD), Phelps (BSD), Thornton (ESD)

Melting permafrost will result in increased microbial degradation of ancient carbon to CO_2 and CH_4.



Hypotheses: Water saturation and the resulting pH from microbial activity will determine the amount and ratio of CO_2 and CH_4 released.





Sediment microcosms from several depths monitored for metabolites, gases, pH; then incorporated into CML4

Modeling long-term population resettlement under climate change scenarios

- Migration is a common behavioral response to resource insufficiency, displacement, and insecurity, which are plausible consequence of climate change
- Understanding human response to climatic extremes and the local, regional and global distribution of resources provides insights into potential migration and resettlement patterns
- The objective is to construct a computational model of population dynamics that
  - Describes displacement, migration, and resettlement as a consequence of vulnerability to climate change
  - Achieves significant advances in predictive approaches to migration analysis through simulations
  - Is high resolution; Spatially and temporally explicit; and Quantitative
- Two scenarios to be explored as case studies
  1. Climate change and water resources in Sub-Saharan Africa
  2. Sea level rise in coastal Bangladesh